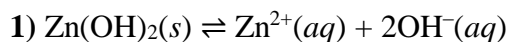


## ANSWERS Solubility with change in pH

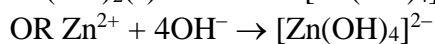


When pH is less than 4 / low,  $[\text{OH}^-]$  is decreased due to the reaction with  $\text{H}_3\text{O}^+$  to form water,

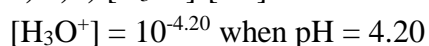
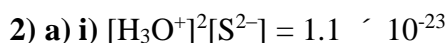


so equilibrium shifts to the right to produce more  $[\text{OH}^-]$ , therefore more  $\text{Zn(OH)}_2$  will dissolve.

When pH is greater than 10 / high, then more  $\text{OH}^-$  is available and the complex ion (zincate ion) will form.



This decrease in  $[\text{Zn}^{2+}]$  causes the position of equilibrium to shift further to the right, therefore more  $\text{Zn(OH)}_2$  dissolves.



(remember from Year 12 Chemistry:

$$\text{pH} = -\log [\text{H}_3\text{O}^+]$$

therefore...

$$\text{inverse log} - \text{pH} = [\text{H}_3\text{O}^+]$$

$$[\text{H}_3\text{O}^+] = 6.31 \times 10^{-5} \text{ mol L}^{-1}$$

$$[\text{S}^{2-}] = \frac{1.10 \times 10^{-23}}{(10^{-4.20})^2}$$

$$= 2.76 \times 10^{-15} \text{ mol L}^{-1}$$



$$4.90 \times 10^{-18} = [\text{Fe}^{2+}] \times 2.76 \times 10^{-15}$$

$$[\text{Fe}^{2+}] = 1.78 \times 10^{-3} \text{ mol L}^{-1}$$

i.e., solubility of FeS is  $1.78 \times 10^{-3} \text{ mol L}^{-1}$  when the pH of the solution is 4.20.

3) When hydrogen sulfide is bubbled through a solution containing  $\text{Cu}^{2+}$  and  $\text{Zn}^{2+}$  the following equilibrium is established.



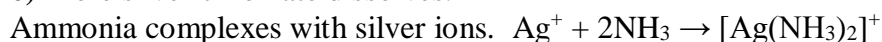
As the pH of a saturated solution (by the addition of HCl) decreases, the equilibrium shifts in the reverse direction reducing  $[\text{S}^{2-}]$ .

For precipitation to occur  $\text{IP} > K_s$ . Hence only the metal sulfide with the lowest  $K_s$  will precipitate. In this case CuS as  $\text{IP}(\text{CuS}) > K_s(\text{CuS})$ . The ZnS will not precipitate. As the pH then decreases  $[\text{S}^{2-}]$  will increase. This enables metal sulfides with larger values of  $K_s$  in this case ZnS, to precipitate as well as the CuS.

4) When the pH is decreased,  $[\text{H}_3\text{O}^+]$  will increase. The  $\text{H}_3\text{O}^+$  will react with the  $\text{OH}^-$  and therefore remove them from the equilibrium. This will cause the reaction to replace some of the removed  $\text{OH}^-$ . As a result more  $\text{Fe(OH)}_3$  will dissolve, so decreasing the pH will increase the solubility of  $\text{Fe(OH)}_3$ .

5) Raising the pH will increase the concentration of  $\text{OH}^-$  ions. This will initially cause additional precipitate to form. Once the pH has been increased sufficiently (enough  $\text{OH}^-$  has been added) the formation of a complex ion with  $\text{Zn}^{2+}$  will occur, lowering  $\text{OH}^-$  ion concentration in solution. Thus the precipitate will redissolve as a complex ion and less precipitate will be at the bottom of the test tube.

6) More silver chromate dissolves.



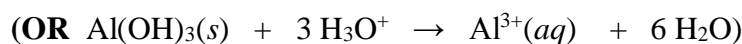
This removes silver ions from the equilibrium mixture. The silver chromate equilibrium will shift to the RHS.

**Note:** Accept  $\text{NH}_3$  solution increases  $\text{OH}^-$  ion concentration so that  $\text{Ag}^+$  reacts with this and precipitates out of solution (as  $\text{Ag}_2\text{O}$ ). Hence, less  $\text{Ag}^+$  in solution results in more  $\text{Ag}_2\text{CrO}_4$  dissolving.



### Acidic conditions

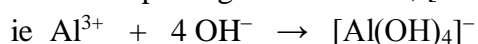
When the pH is less than 4,  $[\text{H}_3\text{O}^+] > [\text{OH}^-]$  and the  $[\text{H}_3\text{O}^+]$  ions react with  $\text{OH}^-$  ions from  $\text{Al}(\text{OH})_3$ .



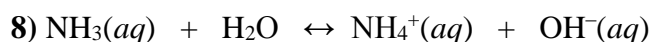
The decrease in  $[\text{OH}^-]$  from the solubility equilibrium causes the position of equilibrium to shift further to the right so that more  $\text{Al}(\text{OH})_3$  is dissolved.

### Basic conditions

When the pH is greater than 10,  $[\text{H}_3\text{O}^+] < [\text{OH}^-]$  and the  $\text{OH}^-$  ions react with  $\text{Al}^{3+}$  ions from  $[\text{Al}(\text{OH})_4]^-$



The decrease in  $[\text{Al}^{3+}]$  from the solubility equilibrium causes the position of equilibrium to shift further to the right so that more  $\text{Al}(\text{OH})_3$  is dissolved.



As  $\text{NH}_4\text{Cl}$  dissolves  $[\text{NH}_4^+]$  is increased. This causes the equilibrium to move to favour formation of reactants so that  $[\text{OH}^-]$  is decreased. As  $[\text{OH}^-]$  is decreased,  $[\text{H}_3\text{O}^+]$  is increased and pH is decreased.

$$9) [\text{Mg}^{2+}][\text{OH}^-]^2 > 7.10 \times 10^{-12}$$

$$0.555 \times [\text{OH}^-]^2 > 7.10 \times 10^{-12}$$

$$[\text{OH}^-] > 3.58 \times 10^{-6}$$

$$\text{Minimum pH} = 8.55$$